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USA RADCON-ALPHA TEAMS: FIELD EXERCISE, 1982

John E. Kammerer, Editor

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A joint field training exercise has been held primarily as a rehearsal for the DOD/DOE NUWAX-83 but to satisfy the training requirements of FM-3-15. Participants in the field exercise included the Sierra Army Depot Alpha Team, the Seneca Army Depot Alpha Team with the RADCON Team acting as host. The three-day event was dedicated to classroom training, a field exercise in Plutonium Valley and critique/analysis/data reporting state-of-the-art instrumentation was used in conjunction with standard equipment.

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I. INTRODUCTION

A. Objectives

The objectives of the RADCON Team exercise described in this report were:

1. Satisfy the training requirement specified in FM 3-15,

2. Provide training, field experience, and coordinate operational readiness to the RADCON Team, Sierra Army Depot Alpha Team, and Seneca Army Depot Alpha Team,

3. Satisfy such technical requirements as implementing standardized instrument calibration and check-out procedures and evaluating advanced state-of-the-art instrumentation under realistic field conditions,

4. Evaluate operational procedures established as a result of lessons learned during NUWAX-81, and to

5. Serve as a rehearsal for NUWAX-83.

B. Background

The Army Radiological Control (RADCON) team(s) mission is to advise the On-Scene Command, who is a general officer, or the Nuclear Accident and Incident Control Officer on all the radiological aspects of the accident or incident. The team(s) also perform detailed surveys for alpha and beta gamma radiation; supervise radiological contamination control, disposal of radioactive waste, and decontamination; and provide health physics and radiological safety services. Since the formation of the teams in 1958 (originally called PLUCON Teams), there have been several accidents/incidents that have occurred that required RADCON action. These accidents/incidents have ranged from the SL-1 Reactor Accident in 1961 to surveys of various government facilities and to participation in the recent NUWAX exercises. Reference 1 contains a detailed description of the team's organization, capabilities, and resources.

The RADCON Team is required by regulation[2] to maintain its readiness and expertise at a high level of proficiency. Recent participation in the joint DoD/DoE NUWAX-79 and NUWAX-81 exercises revealed the desirability of incorporating ALPHA team assistance into the RADCON Team operations. During the NUWAX-81 exercise, it was clear that the RADCON

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[1] D.L. Rigotti (editor), The US Army RADCON Team: Organization, Capabilities, and Resources, ARBRL-MR-02954, Sep 79, US Army Armament Research and Development Command, Ballistic Research Laboratory, Aberdeen Proving Ground, MD (AD A076168).

[2] FM 3-15, Nuclear Accident Contamination Control, Nov 75, Department of the Army.

mission could not have been effectively accomplished in a timely manner without the assistance of the ALPHA Team from the Sierra Army Depot (SIAD). Thus, in order to more effectively utilize the ALPHA teams in future emergencies of the magnitude of NUWAX-81, permission was sought and granted by DARCOM to include the ALPHA Teams from both Seneca Army Depot (SEAD) and SIAD in this year's RADCON Team training exercise.

Instrumentation for performing field surveys is undergoing continual development and improvement as state-of-the-art advances are made in both radiation detectors and electronics. As part of the RADCON Team's effort to maintain state-of-the-art equipment, it is necessary to test developmental models under field conditions. Recently, two different advanced electronic packages have been developed for use with the Field Instrument for the Detection of Low Energy Radiation (FIDLER). This field exercise provided the opportunity to perform the necessary field evaluations.

The exercise was planned to be a 3-day event with 1 day devoted to classroom training. The classroom training would cover six different functions that the RADCON team performs; thus, six stations were established: air sampling techniques, survey techniques, dressout procedures, Hot Line management, and administrative matters. The second day was devoted to a field exercise and the third day was devoted to critiques, data organization and analysis, and report writing.

Participants in the training exercise included 21 RADCON Team, 3 SEAD, and 14 SIAD personnel. The field exercise took place at Area 11, Plutonium Valley (Figure 1) of the Nevada Test Site (NTS) during the week of 10 May 1982.

II. APPROACH

A. Exercise Plan

On 10 May all participants arrived in Las Vegas, proceeded to the Nevada Operations Office (NVOO) where security badges permitting access to the Nevada Test Site (NTS) were issued. Representatives from SEAD, SIAD, and the RADCON Team then met to check out instrumentation and coordinate the following days' activities:

All exercise participants met at the theater in Mercury, Nevada, at 0800, 11 May 82. A 2-hour briefing on REECO RADSAFE Emergency Operations and Procedures was given in the theater. Following this briefing the classroom training sessions were conducted in the theater since high winds precluded an outdoor arrangement.

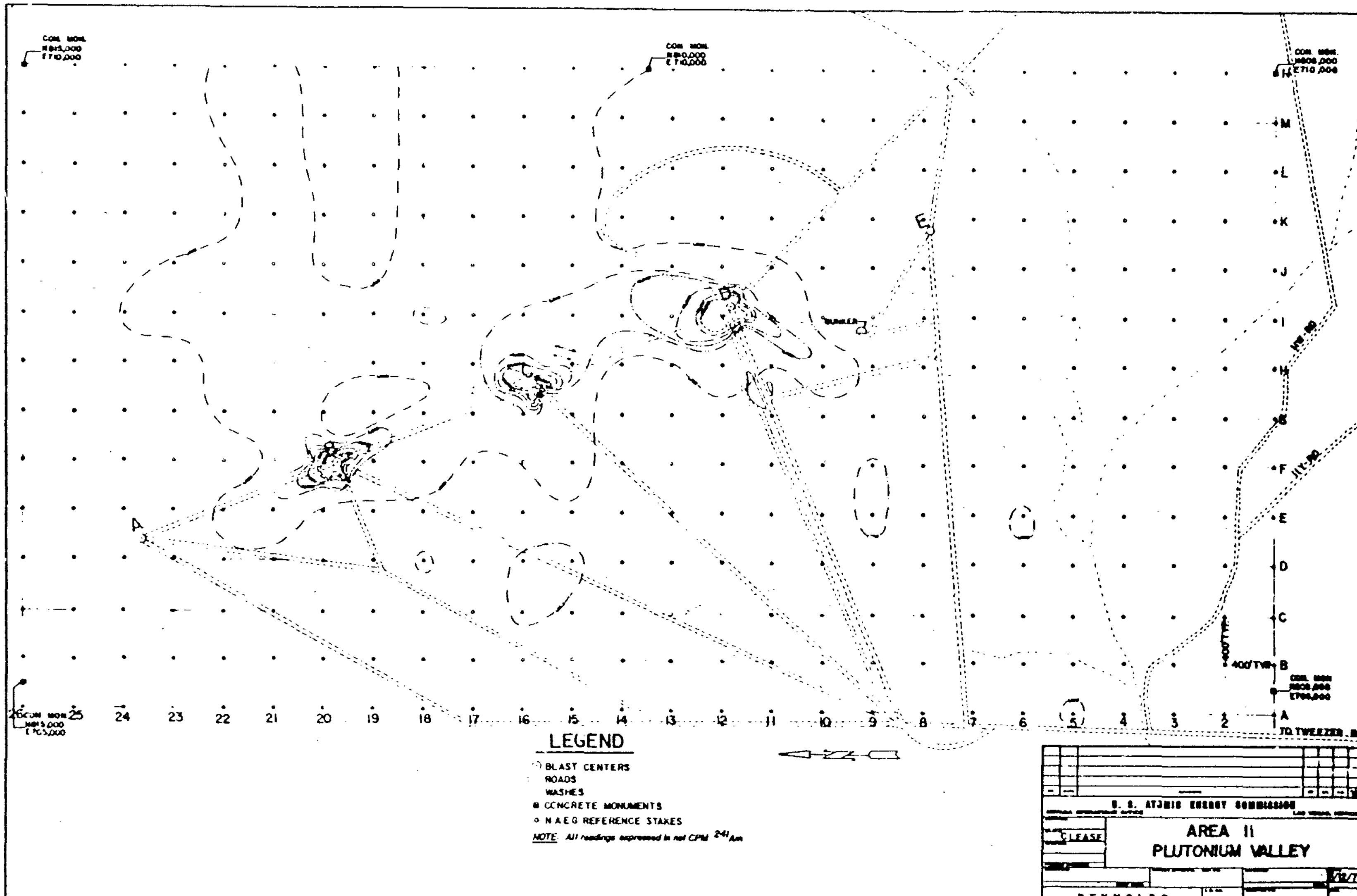


Figure 1. Area 11, Plutonium Valley, NTS

The classroom training consisted of the following six stations:

Title	Instructors
Instrument Familiarization	Morrissey/Taylor
Air Sampling Techniques	Crisco/Ralph Romanelli
Survey Techniques	Rainis/Miller
Dress-out Procedures	Kammerer/Klopcic
Hot Line Management	Wilsey/Schmoke
Administrative Matters	Rigotti/McNeilly

The remainder of the personnel (those not conducting the training) were assigned to the following trainee groups:

Group I	Group II
John Jacobson - Leader	John Kinch - Leader
Jim West	Tom Murphy
Ken Hess	Mr. Whitter
Mike Bennett	Royce Jacobs
Donald Quinton	Bob Crutcher

Group III	Group IV
Joe Maloney - Leader	Mike Vogel - Leader
Rich Romanelli	Lisa Kauzlarich
Ray Dunquez	Ms. Van Dusen
Keith Palmer	Dennis Clemens

Group V	Group VI
Don Lane - Leader	John Evans - Leader
Jim Schall	Ray Langley
Mr. Milligan	Adam Zimmerman
Neal Smith	Dick Eaton

On 12 May all participants met at the Mercury theater at 0730 and then proceeded to the CP as a group. (It was necessary to obtain an operations permit from CP 2 prior to proceeding to the field.) After coordinating with the REECO RADSAFE unit, the exercise team proceeded to Plutonium Valley by exiting Mercury Highway at Tweezer Road (~ 2 miles

North of CP). Once at Plutonium Valley ANTI-C clothing was issued from the REECO RADSAFE truck and instructions were given as to the placement of our vehicles. The team proceeded to the allocated position and set up the control operations in preparation for entry into the hot area. A final operations plan review was conducted just prior to entry into the hot area in order to assure complete understanding of the plan by all participants. The exercise operations were performed in accordance with the instructions received during the classroom training session with the various instructor assuming responsibility for those operations that they had taught.

Two teams were formed with one team entering the hot area and performing a contour survey while the second team maintained Hot Line operations. It was expected this team would be in the field no more than 2 hours. Upon exiting the hot area, operations were secured and a critique was conducted. After a suitable rest period, the team that operated the hot line suited up and entered the hot area to perform a grid survey while the other team operated the Hot Line. Again maximum time in the field was 2 hours. Again upon exiting the hot area, a critique was conducted.

The teams were as follows:

BLUE	RED
Morrissey	Klopcic
Crutcher	Evans
Kauzlarich	Jacobs
Whitter	West
Crisco	Taylor
Kammerer	Ralph Romanelli
Bennett	Van Dusen
Eaton	Dunquez
Rainis	Miller
Schall	Lane
Zimmmerman	Rich Romanelli
Murphy	Langley
Vogel	Schmoke
Mulligan	Quinton
Clemens	Ibach
Palmer	Smith
Maloney*	Jacobson*
Wilsey*	Kinch*

*These individuals were not actual team members but accompanied the respective teams for the purpose of observing operations, answering questions, etc., and preparing a critique of the hot area operations. Also, Mr. Hess was the central collection point for all data and he also acted as recorder, keeping a chronological record of events.

Operations in the hot area consisted of four four-man teams using the FIDLER with PRM-5, LUDLUM, and RASCAL electronic packages. One micro-R (μR) meter was assigned to one of the four-man teams. Readings were taken at regular intervals and recorded, and stakes were inserted into the ground at such intervals that reasonable contours and grids were established. Comparability of all FIDLER readings was possible since all units were properly standardized before entering the hot area. PAC-1S alpha meters were NOT used in the hot area but were also used as the primary monitoring instrument at the Hot Line. Also, the Beta/Gamma instruments were available at the hotline if sufficient intensities were detected by the μR meter.

B. Instrumentation

Each team of four which entered the radiation field carried a micro-R meter and a FIDLER probe with an appropriate electronics package. The micro-R meters were calibrated using a Cesium gamma-ray source with an energy of 661 kev. The FIDLER probe with its electronic package calibrated for the 60 kev energy peak from a ^{241}Am source. The calibration of this instrument was performed using the following standard method:

1. Turn the instrument on after attaching the FIDLER probe. (Allow a 3-minute warmup.)

2. Check battery condition.

3. Place the ^{241}Am source very close to the probe.

4. Place the Gross-PHA switch in the GROSS position. Select the HV-1 position on the high voltage select switch.

5. For the PRM-5 electronics package, adjust the matching high voltage control screw counterclockwise (decreasing high voltage) until the count rate is very low. At this point begin to increase the high voltage (clockwise rotation of the adjusting screw). As the voltage increases, the count rate will also increase. The voltage should be continuously increased until no noticeable increase in countrate is produced by the high voltage control, i.e., no noticeable increase for approximately three quarters (3/4) of a turn. This is the plateau region of the integrated counts curve and is a reasonable operating point for the instrument.

   a. The adjustment of the FIDLER probe with the Ludlum 2220 electronic package differs slightly. For this system, the high voltage of the tube is set at 1150 V (a reasonable operating voltage of the tube). The threshold control is then increased until the count rate is low. Then as the threshold control is reduced, the count rate will increase. This threshold should be lowered until no noticeable increase in countrate is observed. This is the plateau region of the integrated counts curve.

6. The instrument being calibrated was then placed in the "window" mode. For the PRM-5 this meant putting the GROSS-PHA switch in PHA position and for the Ludlum 2220, the "IN-OUT" switch to the IN position.

7. The window widths were then selected. For the PRM-5, the window control screw located inside the instrument case was given five full turns. For the Ludlum, a window of 050 was set using the window control on the front panel.

8. The instrument was then finely adjusted using either the high voltage (PRM) or the threshold control (Ludium 2220) for a maximum countrate.

The instrument has now been calibrated for a small window encompassing the 60 kev ^{241}Am photo peak. Each instrument was standardized just prior to entry and immediately upon exit from the radiation area. This standardization procedure was performed at a station provided adjacent to the hotline. The source-to-detector distance was 30 cm. A copy of the form used to record these numbers is shown in Figure 2. By use of this standardization and a previous calibration of the FIDLER probe, the concentration of Plutonium per square meter can be easily calculated as detailed in Appendix A.

C. Dress-Out Procedures

The dress-out procedure utilized during the field exercise was as follows:

(Step-by-step in following order)

1. Don one set coveralls and button up

2. Slip plastic bags over shoes
   Tuck plastic inside coverall leg

3. Slip on boots
   Blouse coverall leg over boots
   Tape leg to boot

4. Tape seam, pocket, opening on coveralls

5. Don surgeon gloves over coverall sleeves
   Tape gloves to sleeve

6. Don second set coveralls
   Blouse coverall leg over boot
   Tape leg to boot

7. Don surgeons cap (Optional)

8. Adjust respirator to face

FIDLER Standardization Data Sheet												
Probe Serial No.	PRM-5/SN	Ludlum 2220				RASCAL				Countrate in Cpm	Countrate out Cpm	Operator Name
		SN	HV	Thr.	Win.	SN	HV	Thr.	Win.			

Figure 2. FIDLER Standardization Data Sheet

9. Put hood over respirator

10. Pull on cotton gloves over coverall sleeve
    Tape gloves to sleeves

11. Tape seam, pocket, openings on coverall

12. Tag or tape name to front and back coverall

The following techniques were emphasized:

A. Tape openings thoroughly closed, but loosely

B. Tab 3-4" on end of each taping

C. Blouse sleeves/legs fully

D. Tape hood loosely - don't restrict head movement

E. Use "BUDDY" system

It should be noted that for this exercise only one set of ANTI-C clothing was necessary. If a real incident occurred, one would normally use double ANTI-C suits.

D. Hot Line Operations

1. Hot Line Establishment

The hot line by definition is that line which separates the contaminated area from the contamination reduction area and was established as follows:

a. Each team dressed out in full protective clothing according to procedures outlined under the Dress Out Procedures at the control point. The control point was established upwind of the accident site.

b. An advance party which included the team leader, and one additional team member, proceeded from the control point toward the accident site. Their equipment included a FIDLER, an E520, a two-way radio, and a red marking stake.

c. The point at which the radiation level reached three times background was marked with the stake. This represented the location of the Hot Line.

d. The remaining team members were then summoned by radio.

e. An exclusion barrier was marked by engineer tape. It was a minimum of 100 feet to the left and right of the stake marker and approximately perpendicular to the wind direction. The tape should have been staked at a height of approximately 1 meter whenever possible. However, since no equipment was

available to support the engineer tape, it was laid long the ground to mark the Hot Line.

2. Equipment Setup

a. An air sampler was set up adjacent to the Hot Line as shown in Figure 3.

b. Heavy plastic sheeting was laid perpendicular to the Hot Line (Figure 3) on which personnel exiting the hot area stood for removal of protective clothing.

c. Heavy plastic sheeting was also laid parallel to and inside the Hot Line for placement of instruments upon returning from the hot area.

d. Large trash cans with large plastic bag liners were placed in a line perpendicular to the Hot Line.(See Figure 3.) These were for waste tape, cloth booties, coveralls and head covers, respirators and surgeons gloves.

3. Entry into the Contaminated Area

It was the responsibility of the Hot Line personnel to conduct a final check of the dress-out of personnel entering the hot area. They checked for proper taping of protective clothing to assure that there were no exposed areas. A check was also made for proper fit of the respirators.

4. Return from Hot Area

a. Personnel returning from hot area placed all instruments and survey data sheets on the plastic located inside the contaminated area (Figure 3).

b. They then moved to the Hot Line exit in a single file at the two exit points and prepared for removal of protective gear in accordance with the following procedure:

1. While in the hot area, brush off dust from coveralls.

2. Remove all tape from outer clothing and deposit in waste receptacle.

3. Sit down on hot side chair without placing feet on pad.

4. Place feet, with plastic bags, on pad after removing shoe covers; put shoe covers in coverall receptacle.

5. Remove cotton gloves (do not contaminate clothing); put gloves in coverall receptacle.

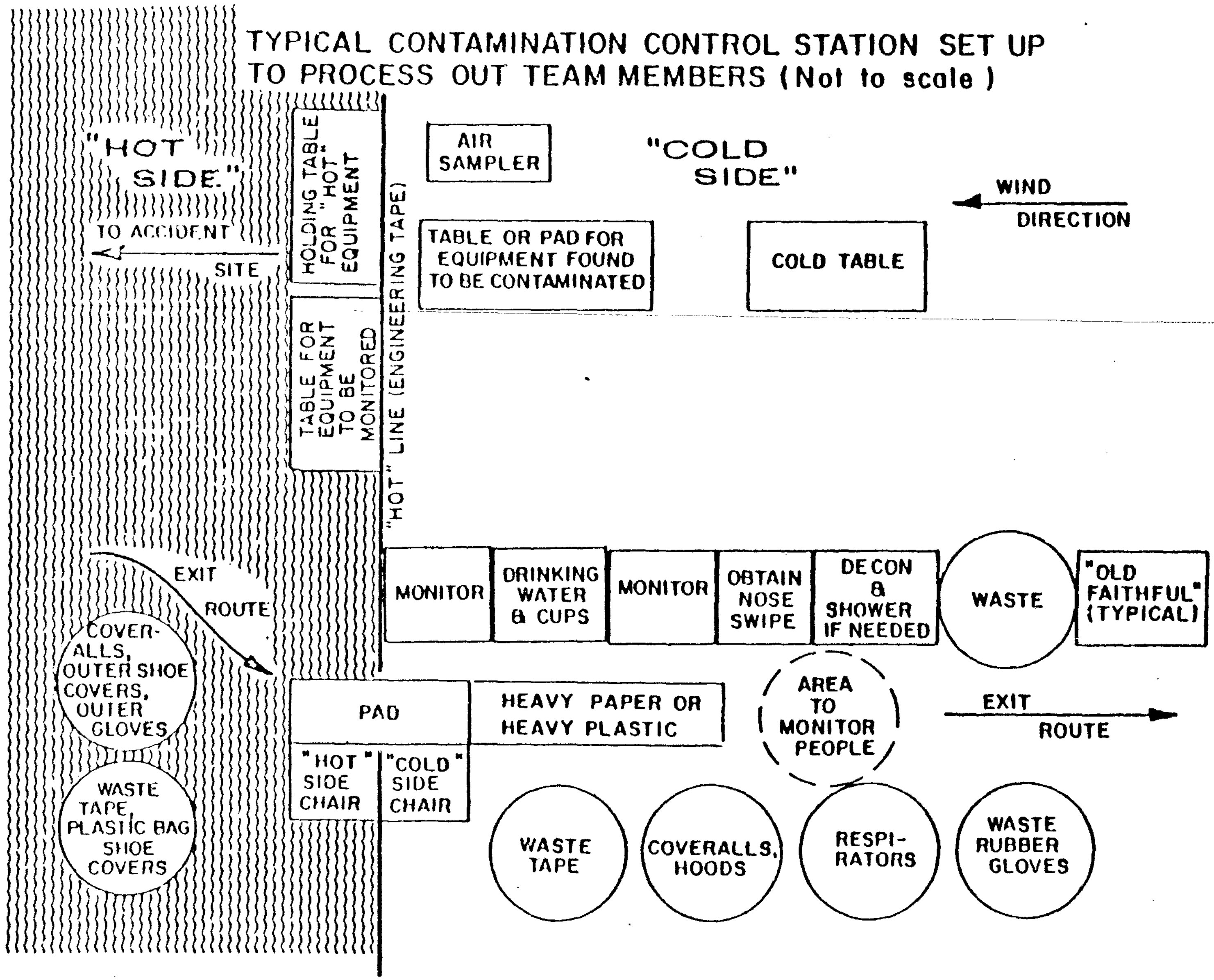


Figure [illegible]. Typical Contamination Control Station Setup to Process Out Team Members (Not to Scale)

6. Remove plastic bag shoe cover from right foot, have foot monitored, and if OK, place foot on cold side; put plastic bag in waste receptacle.

7. Slide to cold side chair; do not cross left foot over Hot Line.

8. Repeat step 6 for left foot.

9. Stand up and remove coveralls.

10. Remove respirator and hood without touching face or hair; place respirator in respirator receptacle and hood in coverall receptacle.

11. Remove surgeons gloves; do not touch skin or clothing.

12. Be monitored.

13. Decontaminate contaminated areas if necessary and verify decontamination.

E. Survey Procedures

The survey procedures to be used for the training exercise were based on the following considerations:

1. There would be two teams of approximately equal size.

2. The job of the first team was to define the contaminated area, especially the 10X and 20X background lines.

3. The second team would refine the area survey performed by the first team by performing a grid survey.

4. The exercise area would not contain a convenient reference point for the surveys.

5. The particular methods employed at the site would be at the discretion of the two team leaders and would be based heavily upon the scenario as presented.

The classroom training provided for a general discussion of the various techniques that are employed by the RADCON team. However, emphasis was placed upon the particular surveys needed for the present exercise. The details of these surveys are sensitive to the assumptions employed and listed at the beginning of this section. In addition, it was known that the exercise would take place in Area 11, Section D -- a section of Plutonium Valley.

Two different surveys were performed by the two groups. The mission of the first group was to define a contaminated area by means of a contour survey while the second group performed a grid survey on the contaminated area. Based on the assumptions above, the area to be

surveyed is basically featureless. In addition, the contamination from Area D is known to overlap the contamination from the adjacent Area C. Therefore, in order to complete these two surveys in the time available for the exercise, a number of artificial constraints were incorporated into the survey procedures for this exercise.

a. Contour Survey

The contour survey was performed for two contamination levels: 10X and 20X background. (Note: Background was defined for each instrument in a "cold" area with the window set for the ^{241}Am 60 kev gamma ray. The instrument was carried so that the face of the probe was 30 cm above the ground). The survey teams that performed this survey did not proceed past the 20X contour: the "turn-back point." Two of the four teams delineated the 10X contour by the procedures outlined below while the remaining two teams defined the 20X contour at the same time.

Initial entry into the area was made simultaneously by all four survey teams. When the 10X background contour was reached, a reference stake was placed in the ground. The proper placement of this stake was important since it served as the reference point for the remainder of the exercise. Therefore, this stake should not only be firmly placed so that it does not shift in the desert winds but should also be distinctive and visible from all locations in the exercise area.

The four teams were split at this point: two teams continued deeper into the contaminated area to reach the 20X contour being careful to record the distance and compass heading from the reference stake to that contour. The two teams that remained at the 10X contour determined this contour; each team in an opposite sense from one another. Each team recorded on their data sheets whether they went clockwise or counterclockwise as well as the contour line they were determining. (Note: Since we were field testing the new FIDLER's, all instrument readings were recorded on the data sheets).

From their respective starting points on the contour, a survey team paced off ten (10) paces -- approximately 25 feet -- along the contour and placed a color-coded stake appropriate to that contour. All instruments were read and the readings recorded. Also recorded was the line-of-sight compass reading (relative to magnetic north) from this position to the reference stake. These readings were repeated until the contour was completed: the 10X and the 20X contours, respectively. The teams then exited the hot area being careful to avoid the turn-back contour.

b. Grid Survey

For training purposes the second survey group ignored the turn-back contour established by the first group. As before, there were four teams which consisted of three FIDLER instrument operators and one data recorder. The only area to be surveyed was the area marked by the previous survey as guide. A base line for this survey

was established by stakes at intervals of eight (8) paces. These were numbered on a map which also gave the compass heading of the base line. The map reference numbers were used to identify the line walked by a survey team.

Starting from the center of the base line, two teams were responsible for each half of the survey. It was suggested that the two teams doing one side of the survey walk alternate paths (by starting from adjoining stakes on the base line) using their compasses to provide a direction which was reasonably perpendicular to the base line. Readings were recorded every eight paces -- approximately 20 feet -- along the line. To avoid confusion, each team returned to the base line before starting another survey along a grid line.

The readings of the several types of FIDLER instruments used in the exercise can be translated from the meter readings in counts per minute to a measure of the areal dispersion of the contaminant (plutonium) in micrograms per square metre. The details of the derivation of this conversion factor were contained in Appendix A. However, for a typical FIDLER instrument, one multiplies the meter reading by a constant of 9.1×10^{-4} (although this number will vary somewhat between instruments) to convert counts per minute to micrograms of plutonium per square meter.

F. Air Sampling Procedures

The following material was taught during the classroom exercise:

The air sampling equipment for a field station included a Staplex High Volume Air Sampler, 10 cm diameter Whatman 41 filter paper, a tripod, and a portable gasoline AC generator. In setting up the sampler, the top screw-on ring was removed so that the mesh screen and screen crossbar support are exposed. A piece of the 10 cm Whatman-41 paper was placed on the screen and the outer ring fastened so that a good seal between the proper, outer ring, and inner surface was achieved. The sampler was affixed to the top of the extended tripod at approximately one metre above the ground surface. The sampler cord with the switch in the OFF position was plugged into the operating generator. The sampler was switched ON and the time noted when sampling began. The sampler was examined for proper function and the flow rate was read from the flow metre on the rear of the sampler. The time that sampling began and ended and the beginning and ending flow rates were recorded on the air sample data form.

Air samplers will normally be positioned at four locations at an accident site. A background sampler is placed 610 m (2000 ft) upwind from the accident site. At lease a 30-minute sample is taken for use in determining background radioactivity. A second sampler is placed at the Hot Line and is operated continuously during during all operations since there is a risk of resuspension. The filter is changed about every 60 minutes. A third sampler is positioned 25 m downwind of the center of the accident site to determine hazards in the immediate area. The sampler is operated continuously with filter changes about every 60

minutes. The fourth sampler is placed downwind at a distance dependent on wind velocity. The following table assists in selecting the location for the far downwind sampler.

Wind Speed mph	Wind Speed knots	Downwind Distance Metres
6-10	4-9	1050
11-15	10-13	1550
16-20	14-17	2050
>20	>17	2550

A sampler at this far downwind position is operated continuously until assay indicates no danger. The filter is changed about every 60-120 minutes.

There are two types of air sample analyses that may be performed. The field type gives an order-of-magnitude estimate of the alpha airborne contamination, but if quick results are necessary, it will be the most used method. For a more accurate estimate of the airborne alpha contamination, the so-called laboratory assay method would be used. This method requires a much longer time to obtain final results and needs more rigidly controlled conditions for performance.

With the field analysis method, the 10 cm Whatman 41 filter paper containing alpha activity is measured by placing the PAC-1SA (JM-120/PD) alpha survey probe in <u>near</u> contact with the exposed side of the paper, as nearly centered as possible. The time and alpha countrate are noted. A background sample, which has decayed the same length of time since sampling ceased, must also be read. The following formula is used to obtain the alpha concentration.

$$\mathrm{Conc} = \frac{\mathrm{Cpm} \times 10^{-10}}{\mathrm{Cfm} \times \mathrm{Time}} \qquad (1)$$

where

Cpm = count per minute for sample

Cfm = flow rate $ft^3\ min^{-1}$

Time = sample time in minutes

Conc = $\mu Ci/ml$.

The 10^{-10} is the correction factor to convert the measurement on a 10 cm filter paper to $\mu Ci/ml$. The count per minute for the sample is obtained by subtracting the background sample count per minute.

For an accurate alpha determination, the laboratory assay method is required. The Eberline portable alpha counter is used for this analysis. First, a 5 cm diameter disk is cut from the 10 cm filter. At about 4 hours after sampling is discontinued, this 5 cm disk is placed

in the counter and counted 10 minutes or more dependent upon the countrate. The sample is recounted approximately 24 hours after cessation of sampling. The same procedure is followed with the background sample. The 4-hour and 24-hour times are used to allow material Radon and daughters to decay. At the end of 4 hours ^{222}Rn and daughters are considered completely decayed. The recount at 24 hr allows an estimate of the ^{222}Rn and daughter decay when used with the 4-hour reading. The count due to long-lived alpha emitters may be calculated by the equation:

$$C_{LL} = \frac{C_2 - C_1 e^{-2 \lambda \Delta t}}{1 - e^{-2 \lambda \Delta t}} \qquad (2)$$

where

C_{LL} = countrate due to long lived isotopes (Cpm)

C_1 = countrate (cpm) from 1st count less counter background

C_2 = countrate (cpm) from 2d count less counter background

t_2 = time of 2d count (~ 24 hr)

t_1 = time of 1st count (~ 4 hr)

$\Delta t = t_2 - t_1$ (hr)

e = base of natural log

λ = 0.0655 (hr^{-1}), the decay constant for $^{222}R_n$

To convert counts per minute for long-lived isotopes to µCi/ml the following equations can be used:

$$\mu Ci/ml = \frac{C_{LL} \times 4.505 \times 10^{-7}}{ft^3 \times 2.83 \times 10^4 \times 0.7 \times E_{fe} \times F} \qquad (3)$$

where

C_{LL} = cpm due to long-lived isotopes

4.505×10^{-7} = conversion of disintegrations per minute per ml to µCi per ml

ft^3 = volume of sample in ft^3

2.83×10^4 = conversion of ft^3 to cm^3

0.7 = alpha counting efficiency on absorption factor for Whatman 41 filter paper

E_{fc} = efficiency of counter (geometry)

F = fraction of filter area countered (for 5 mm disc cut from 10 cm filter would be 0.25)

Air sampling was conducted during the field exercise portion of the training. Immediately upon establishment of the control point, a background air sample was collected for a period of 20 minutes. This sample was measured using PAC-1SA alpha probe 20 minutes following cessation of collection.

The sampler was moved to the Hot Line area and sampling commenced. At 20-minute intervals, the filter was changed. The sampling continued during all Hot Line operations during the morning activities. Sampling was discontinued during afternoon activities since negative results had been obtained during morning sampling. After the Hot Line air sampler was set up and sampling begun, a station approximately 2000 m downwind was hypothetically installed and operated. An actual station was not planned since only one sampler was taken to the site.

Each filter sample was read with the PAC-1SH alpha probe at approximately the same decay time as the background sample initial reading. Because of the lack of an enclosed area out of the wind and dust and of a power supply in the field, the laboratory assay method was not attempted.

III. RESULTS

A. Survey Results

Instruments were calibrated in accordance with the procedures in Section II B. Prior to use in the field, background readings were obtained for each instrument in the vicinity of the Hot Line by the personnel in charge of instrumentation. In addition, the FIDLER detectors -- used in the PHA, or window, mode -- were tested against a standard source, 4.8 μCi, of ^{241}Am. It was noted at this time that, for all of the instruments, the meter readings of the FIDLER in PHA or gross modes were almost the same. Therefore, at the Hot Line area, one can infer that environmental gamma sources contributed few gamma rays higher than the PHA-selected 60 kev peak of ^{241}Am.

1. Contour Survey

Four groups were used to perform the contour survey with four men per group. Each group contained a recorder, a monitor using a FIDLER, another monitor using a micro-R gamma/beta instrument and a staker/compass reader.

The procedure used was essentially as given in Section II E. One significant difference between that outline and the actual procedure was that the contour lines were determined by 20x and 50x background rather than the suggested 10x and 20x levels. This change was made in order to limit the surveyed section to be reasonable in extent, permitting the field measurements to be completed in less than 2 hours.

Another change made in the field was the adoption of a field "standardization" for the four FIDLER instruments employed in the determination of the contours. This was accomplished by locating the 20x level with one instrument, noting the readings of the other instruments, and using those meter readings when following the contour. The meter readings for the 50x level were determined in a similar manner. This procedure was necessitated by the observation that -- in the window mode -- the FIDLER's did not all register 20x background at the same radiation level. This is shown in Table I.

The first and the second modifications are probably due to a small amount of fission products assumed to be present in the area. The presence of a gamma emitting contaminant can be inferred from the data in Table 2 which lists the gamma dose readings taken on the various contours. Clearly these data show a gamma component in the radiation field.

The data from the four survey groups are tabulated in Tables 3 and 4. The form of the data is a sequential list of compass bearings -- and the corresponding back azimuths -- each of which are given for a point which is a "constant" ten (10) paces from the preceding point. All of the points on a given contour are iso-dose as described previously.

These data are displayed graphically in Figure 4. Since the survey procedure used for this exercise results in each data point in the Tables 3 and 4 representing a non-unique spatial location (at most two positions are possible), the following strategy was adopted to display the data:

a. Multiple adjacent points that differed in azimuth by only a few degrees were assumed to be arrayed in a "zig-zag" (oscillating) spatial pattern.

b. Data points that appeared to be due to either a compass or pacing error were corrected according to the sense of the contour line in the vicinity.

2. Grid Survey

The grid survey was also performed by four survey groups configured as previously described. Initially a composite crew was sent out to the reference stake and a baseline for the grid survey established on the basis of the stakes positioned during the contour survey. Along this base line, seven additional stakes were positioned at intervals of eight (8) paces: four were essentially to the north (322°) of the reference stake and three to the south (142°). Survey groups, using each of the eight stakes as a starting point, traveled in the 52° direction: recording instrument readings every 8 paces.

Data obtained in the grid survey are displayed in Table 5. FIDLER determinations are displayed in two ways: meter reading and areal concentration of contaminant. The plutonium concentrations were determined using the calibration for each instrument as tabulated previously

Table 1. FIDLER Meter Readings For Contour Survey

Serial Number	Reading (CPM)	Background Reading (CPM)	Standard Source Reading (CPM)	Contour Location
21768	60K	3K	20K	outer; counter-clockwise
1992	55K	12K	40K	outer; clockwise
1991	30K	8K	45K	inner; counter-clockwise
2164	100K	6K	39K	inner; clockwise

Table 2. Average Gamma Dose Readings for Contour Survey

Meter Serial Number	Background Reading (μR)	Average Reading (μR)	Standard Deviation (μR)	Contour Location
16921	28	85	27	outer; counterclockwise
254	8	7	0.6	outer; clockwise
16922	32	30	2	inner; counterclockwise
261	25	99	18	inner; clockwise

Table 3. Inner Contour Survey Data

Clockwise

Magnetic Heading	Back Azimuth
180°	0°
150°	-30°
120°	-60°
110°	-70°
135°	-45°
140°	-40°
120°	-60° (?)
150°	-30°
160°	-20°
155°	-25°
165°	-15°
165°	-15°
180°	0°
185°	5°
200°	20°
205°	25°
210°	30°
200°	20° (?)
225°	45°
235°	55°

Counterclockwise

Magnetic Heading	Back Azimuth
190°	10°
240°	60°
280°	80°
325°	145°
320°	140°
325°	145°
320°	140°
305°	125°
290°	110°
285°	105°
270°	90°
265°	85°
250°	70°
245°	65°
235°	55°
230°	50°

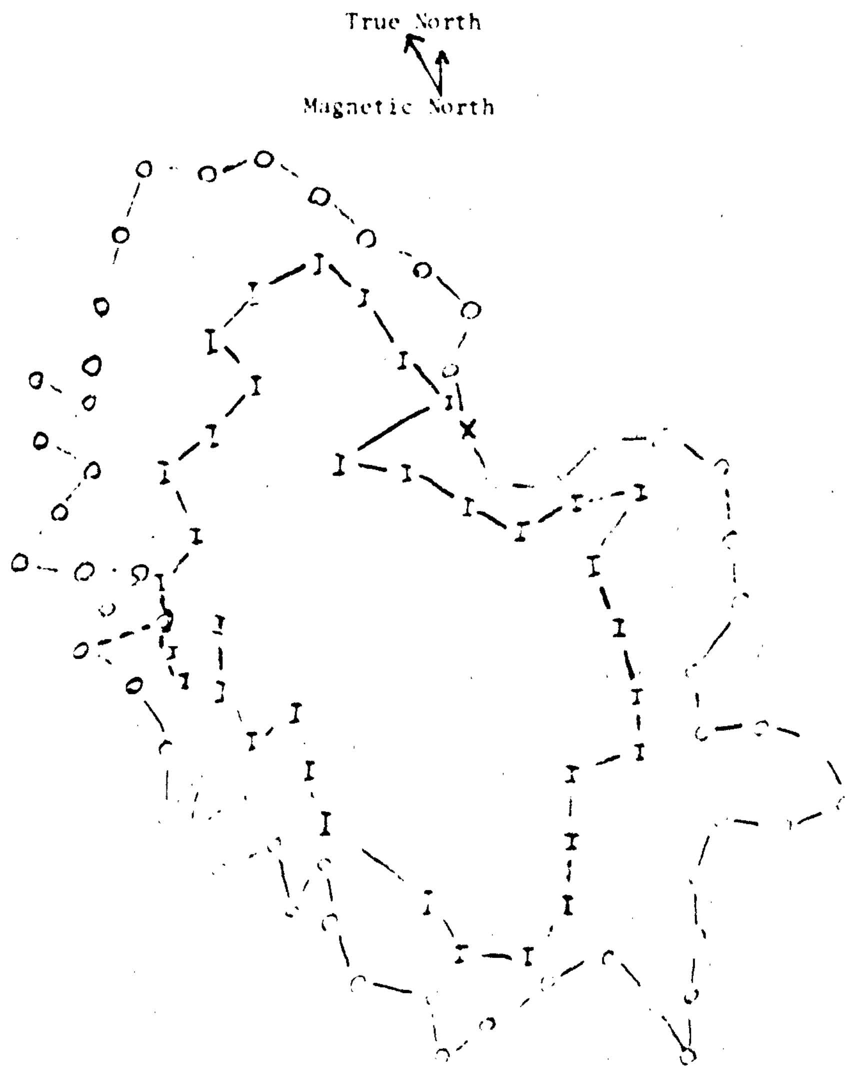
Table 4. Outer Contour Survey Data

Clockwise

Magnetic Heading	Back Azimuth
152°	332°
120°	300°
94°	274°
90°	270°
97°	277°
111°	291°
120°	300°
135°	315°
140°	320°
132°	312°
130°	310°
132°	312°
140°	320°
145°	325°
152°	332°
155°	335°
159°	339°
160°	340°
161°	341°
164°	344°
171°	351°
176°	356°
181°	001°
184°	004°
190°	10°
195°	15°
199°	19°
200°	20°
205°	25°
210°	30°
211	31
215°	35°
216	36°
217°	37°
225°	45°
234°	54
246°	62°

Counterclockwise

Magnetic Heading	Back Azimuth
350°	170°
5°	185°
345°	165°
335°	155°
330°	150°
325°	145°
315°	135°
310°	130°
300°	120° (?)
290°	110°
280°	100°
285°	105° (?)
275°	95°
270°	90°
267°	87°
260°	80°
255°	75°
260°	80°
257°	77°
255°	75°
252°	72°
248°	68°
245°	65°
240°	60°



O Outer contour (20 x background)

I Inner contour (50 x background)

X Reference Stake

Solid lines guide the eye

Dashed lines indicate closure distance

|--| Approximately 25 feet

Figure 1. Isopleths of Surveyed Area

Table 5. Data From Grid Survey

L-1			L-2			L-3			L-4			
FIDLER SN/1991		Micro R SN/	FIDLER SN/1992		Micro R SN/	FIDLER SN/1991		Micro R SN/	FIDLER SN/1992		Micro R SN/	
CPM	μg/m^2	μR	CPM	μg/m^2	μR	CPM	μg/m^2	μR	CPM	μg/m^2	μR	
8K	7	26	400K	272	220	170K	140	32	275K	187	200	Base Line
45K	37	26	250K	170	140	120K	98	36	>500K	>340	420	
200K	164	30	>500K	>340	260	200K	164	40	>500K	>340	800	
150K	123	36	225K	153	160	150K	123	38	450K	306	380	
250K	205	60	250K	170	280	50K	41	31	>500K	>340	400	
>500K	410	100	>500K	>340	600	170K	140	36	400K	272	230	
250K	205	50	>500K	>340	400	45K	37	34	450K	306	320	
50K	41	30	>500K	>340	400	50K	41	32	>500K	>340	600	
45K	37	30	400K	272	380	150K	123	36	>500K	>340	380	
20K	16	25	400K	272	200	45K	37	30	475K	323	380	
25K	20	26	60K	41	130	42K	34	26	250K	170	160	
12K	9.8	28				25K	20	22	60K	41	110	
10K	8.2	30				12K	9.8	26				

Table 5. Data From Grid Survey (Continued)

Center Line			R 1			R 2			R 3			
FIDLER SN/2164		Micro R SN/16930	FIDLER SN/21758		Micro R SN/	FIDLER SN/2164		Micro R SN/16930	FIDLER SN/21768		Micro R SN/16	
CPM	$\mu g/m^2$	μR	CPM	$\mu g/m^2$	μR	CPM	$\mu g/m^2$	μR	CPM	$\mu g/m^2$	μR	
176K	120	120	70K	84		500K	340	160	140K	168		Base Line
>500K	>340	200	190K	274		250K	170	200	170K	204		
500K	340	410	180K	216		450K	306	110	98K	118		
52K	35	310	140K	168		60K	41	110	140K	168		
400K	272	300	110K	132		275K	187	170	61K	73		
>500K	>340	210	270K	324		55K	37	100	96K	115		
75K	51	80	250K	300		275K	187	70	68K	82		
43K	29	60	220K	264		495K	337	170	92K	110		
24K	16	30	75K	90		58K	39	60	106K	127		
6K	4.1	20	48K	58		48K	33	40	42K	50		
			13K	16		15K	10	30	28K	34		
									15K	18		

together with the calculations shown in Appendix A. Note that no μR readings are shown for Lines R1 (first line to the right of the centerline while facing the field) and line R3. In addition, it appears that the FIDLER readings for lines L2 and L4 were taken in gross mode. Hence, they are probably not comparable with the readings for the other lines.

A list of miscellaneous data relative to compass readings and stake locations are contained in Table 6.

B. Air Samples

The results of the background air sample and the two Hot Line samples taken during the exercise are tabulated below. No downwind sample or contaminated area samples were taken for reasons explained in the Procedures section. Also, laboratory analysis of air samples was not performed because of time constraint, lack of an appropriate power supply, and an enclosed area for controlled conditions for such work.

Sample	Sampling Time min	Flowrate CFM	Alpha Reading CPM	Decay Time min	Total Vol ft^3	Concentration μ Ci/ml
Background	20	60	200	20	1200	1.7×10^{-11}
Hot Line #1	20	55	200	20	1100	1.8×10^{-11}
Hot Line #2	20	55	200	20	1100	1.8×10^{-11}

IV. DISCUSSION

A. Survey Data Comparisons

Figure 5 shows FIDLER meter readings obtained from measurements made in January 1975 for Area 11, Site D.[3] Since several years have elapsed between the 1975 data and the current exercise, one would not expect to duplicate quantitatively the earlier data. However, one might reasonably expect the shapes of the separately determined concentration lines to correspond with one another if linear dimensions are comparable. Comparing the shape of the inner contour from Figure 4 with the Strata 5, Figure 5, of the 1975 data, one observes a striking similarity in both orientation and relative shape. The similarity is enhanced if true north (as opposed to magnetic north) is used to plot the contour data.

Some discussion of the instrument readings obtained in this part of the survey is warranted. Noting the μR meter readings in Table 2, we see some discrepancies. Two of the instruments, SN 16921 and SN 261

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3 M.G. White and P.B. Dunaway (editors), The Radioecology of Plutonium and Other Transuranics in Desert Environments, NVO-153 VC-2 (pp 339-348), June 1975, US Energy Research and Development Administration, Nevada Operations Office, Las Vegas, Nevada.

Table 6. Miscellaneous Data

Distance and magnetic bearing from reference stake to the first inner contour stake: 22.5 feet @ 10°

Magnetic bearing from reference stake to bunker: 170°

Magnetic bearing from stake to Hot Line : 261°

Estimated distances from Hot Line to reference stake: 300 feet

Magnetic bearing of base line for grid survey: 142°

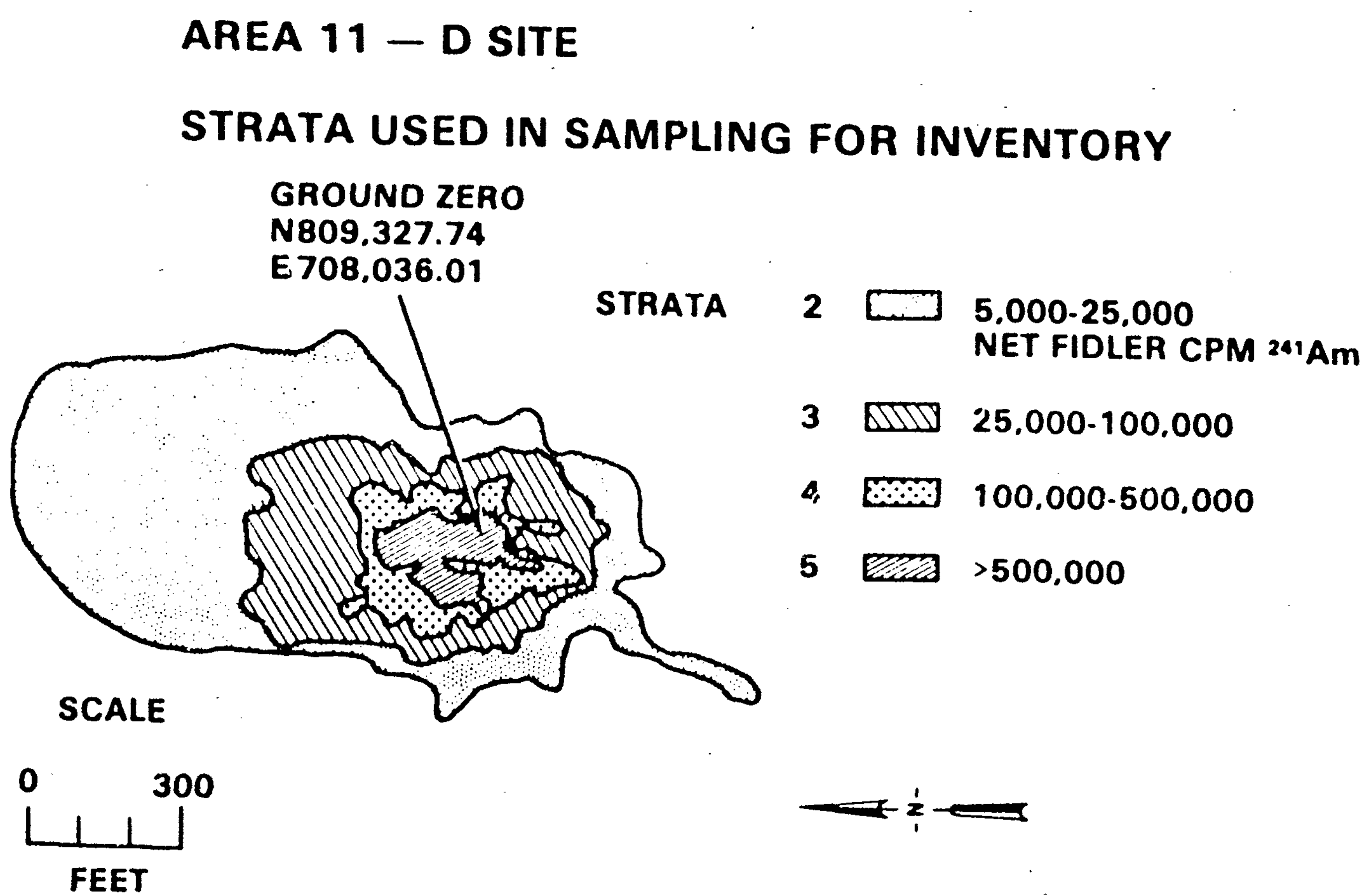

Figure 5. 1975 FIDLER Survey Results

have average readings of 3-4 times background with significant variation as indicated by the standard deviation of the readings. Conversely, the other two meters read essentially background at all points even though they both give a nonzero reading (and hence appeared to the operation as properly functioning instruments). Although it is not apparent from these data, it is suspected that one or both of these latter two instruments have malfunctioned. Thus, the presence of a gamma component might have been overlooked by the instrument(s).

The Absolute FIDLER readings in Table 1 are curious as well. The first two instruments which were employed to define the outer contour line, SN 21768 (Ludlum) and SN 1992, give readings on the standard source which differ by a factor of 1.6 (background corrected) but give readings which are a factor of 0.75 apart in the field. The conclusion reached is that they are gamma emitting isotopes which affect these two instruments since they (presumably) have different PHA-energy settings. This energy-window/crystal-tube resolution problem is exacerbated for the other two instruments employed on the inner contour. For these two instruments, the apparent differences are much greater. Therefore, it can be concluded that the mixed radiation field response of a FIDLER in PHA mode be investigated for a number of crystal-photomultiplier tube assemblies. Otherwise, the calibration technique reported in Appendix A may lead to erroneous results.

The grid survey results show that the largest concentration of plutonium was corresponding to a maximum backing on the FIDLER, 410 $\mu g/m^2$: under the assumptions listed in Appendix A. This means that under these conditions we could not identify the 1000 or 3000 $\mu g/m^2$ levels with the FIDLERs. This could be overcome by an instrument such as the LUDLUM which could set, and hold, a narrow window to reduce the count rate.

The final comment on the data regards the method used for the contour survey. This method is not satisfactory for two reasons. First, every point depends on the previous points and, second, the data are inherently double-valued. It was suggested by the Sierra personnel that the survey technique be modified by using two reference points so that two compass headings would be used to locate a point on the ground. (The distance between these points must be known.) This will eliminate the problems described above.

B. Air Sampling

Air sample field analysis indicated samples taken at the Hot Line were at background levels. Although the results for the two Hot Line samples are both 1.8×10^{-11} $\mu Ci/ml$, the counting error for 200 cpm is 7 per cent. This would place the results within background levels. Furthermore, the field method is not expected to be a precise method but only to quickly gauge an order of magnitude estimate.

C. Critique

1. Operations

The overall critique of the approach of classroom training and a field exercise was very favorable and provided useful training to all participants. The initial briefing by REECO RADSAFE personnel that presented the "Philosophy of Emergency Response" established a beneficial perspective for defining the problem, controlling the problem, the need to document all information relative to the emergency, and the clean-up activities that would be required in a real emergency. The following classroom training allowed for active involvement by all participants in the various functional areas that would be required in emergencies. The small groups (four to five people per group) permitted hands-on experience with the instrumentation, actual dress-out, processing through the Hot Line, and operation of air samplers. The primary problem with the classroom training was that insufficient time was allotted for some stations such as instrument familiarization and survey procedures, and too much time was allotted for such things as administrative matters and air sampling. Future classroom training should be organized such that a comparable amount of time is required at each one. Another comment indicated a desire to include a station to discuss decontamination.

The field exercise in general was considered to be highly successful and beneficial to all participants. The application of the information learned in the classroom training was actually applied and the people experienced first hand the entry into a real Plutonium contaminated area. Physically donning ANTI-C clothing, working with survey instruments in the field, trying to communicate and perform data recording while in ANTI-C clothing, and actually performing a real survey was a valuable learning experience for all participants, in particular, was especially enlightening to people who have never before been required to perform such activities.

The primary criticisms were (1) that the actual field exercise should have been extended to provide 2 days of in the field experience, (2) more time should have been allotted for more instructions to all participants of the specific and detailed procedures to be employed in the field prior to entry, (3) a modicum of confusion was evident during the early portion of the exercise relative to specific assignments to individuals working the Hot Line and on each of the individual survey teams, and (4) no single individual was pre-exercise appointed as a leader of the BLUE or RED teams.

2. Procedures

All of the procedures that were presented during the classroom training and implemented during the field exercise were in principle acceptable by all participants. The primary comments were concerned with more hands-on training with instruments, a standardization of instrumentation and calibration procedures (the SIAD and SEAD depots, for example, do not have the 10 cm diameter staplex air sampler), a need to revise and update FM 3-15, and coordination of dress-out procedures

to preclude a bottleneck at the Hot Line. There were also a number of suggestions and recommendations made that were directed toward improving existing procedures. These suggestions included using prepared data sheets, improving staking techniques, instituting two reference stake survey location procedure, and streamlining Hot Line operations.

V. SUMMARY

A. Conclusion

The 1982 joint RADCON/ALPHA TEAM field training exercise was an unqualified success. The experience of actual field operations in a realistic environment is invaluable and indispensable if adequate emergency response readiness is to be maintained. All of the exercise objectives were met. New instrumentation was tested and found to be superior to existing models. The RADCON/ALPHA teams are not only compatible but each greatly compliments and enhances the capabilities of the other. In a real major emergency, it is doubtful if the situation could be adequately satisfied without the assistance of both groups. As a result of the exercise, the operations and procedures required to participate in NUWAX-83 have been strengthened.

B. Recommendations:

The following recommendations are made:

1. The joint training exercise be continued in future years with the actual field exercise expanded to at least 2 days.
2. The ALPHA Team instrumentation should be upgraded to be compatible with the RADCON Team basic set so that standardized calibration and operation procedures can be established.
3. FM 3-15 be revised and updated to reflect the latest instrumentation and procedures.
4. The LUDLUM electronic package for the FIDLER should replace the PRM-5.
5. The μR meter should be made the acceptable standard beta gamma survey instrument.

Finally, it is strongly recommended that the Army take the initiative to establish a DOD/DOE working group to develop a universal set of standard procedures for employing, calibrating, and interpreting results of survey instruments that are used during emergency radiological operations.

Philosophy of Emergency Response

1. Define Problem
2. Control Problem

   Medical Emergencies top priority

   Establish Control Point Center for Communications

   Put barricades

   Collect environmental samples

   - air
   - water
   - soil
   - bio-assay

   Perform detailed surveys

   - High exposure rate areas
   - Post levels

   Communicate recommendations to proper authorities
3. Document all information

   Have recorder near team leader at CP
4. Clean-up

   Final survey

APPENDIX A

Calculations of Plutonium Concentrations from FIDLER Measurements

Calculations of Plutonium Concentrations from FIDLER Measurements

This appendix reports the calculations required to translate FIDLER meter readings, in cmp, into the areal density of plutonium, in micrograms/square meter, dispersed on the ground. The assumption is made that the plutonium is deposited reasonably uniformly, at least in the vicinity of the probe.

Plutonium of sufficiently pure weapon-grade material can be identified by the detection of Pu x-rays (near the 17 Kev band) associated with the 238-242Pu and 241Am decays. An alternate method is to detect the 60 kev gamma ray emitted during the decay of 241Pu to its daughter, 241Am. This alternate method is preferred when using the FIDLER because it is easier to detect higher energy photons. In order to use either method, however, one must first calibrate the FIDLER and determine its absolute efficiency in detecting either the 17 or 60 kev photons. Subsequently, the mass ratio of plutonium to americum in the contaminant must be known to infer the areal density of the contaminant from the detected photons.

The 239-240Pu/241Am ratio for area D in calendar year 1972, according to Reference A1, was approximately 8. However, the amount of 241Pu and 241Am needed to determine the concentration of Pu was not given. Therefore, it was necessary to assume a 241Pu/241Am ratio for this exercise. In a real situation, the ratio could be obtained from the weapon developer or by having the debris analyzed. The information would probably be in the form of 239-242Pu and 241Am by % mass for a specific date. Table AI contains the concentrations postulated for this exercise. The assumed concentrations are listed in column two while the current levels, calculated by Equations A1 and A2 are listed in column three. These values will be used in this exercise.

Table AI. Assumed Assay of Plutonium for Exercise

ISOTOPE	% by mass (May 1972)	% by mass (May 1982)	Half-Life (years)
^{239}Pu	81.7	81.7	24,300
^{240}Pu	5.6	5.6	6,600
^{241}Pu	1.6	0.95	13.2
^{242}Pu	0	0	380,000
^{241}Am	11.1	11.55	470

[A1] "The Radioecology of Plutonium and Other Transuranics in Desert Environments," United States Energy Research and Development Administration, Nevada Operations Office, NVO-153 UC-2, January 1975.

$$\% \text{ mass } 1982 = \% \text{ mass } 1972 * e^{-\lambda t} \quad \text{(A1)}$$

where $\lambda = \dfrac{\ln 2}{t_{1/2}}$

$t_{1/2}$ = isotope half-life

and t = decay time (May 1972 to May 1982)

$$\%\text{mass } {}^{241}\text{Am}(1982) = \%\text{mass } {}^{241}\text{Pu}(1972) \rightarrow {}^{241}\text{Am}(1982) - \%\text{mass } {}^{241}\text{Am}(1972) \rightarrow {}^{237}\text{Np}(1982) \quad \text{(A2)}$$

where ^{241}Pu(1972)--> ^{241}Am(1982) signifies the decay of ^{241}Pu between 1972 and 1982 into ^{241}Am

and ^{241}Am(1972)--> ^{237}Np(1982) signifies the decay of ^{241}Am between 1972 and 1982

Knowing the Pu/Am ratio, the next step is to determine the efficiency for the FIDLER probe and its associated meter in detecting 241 Am. This has been documented in Reference A2. The calibration constant equation, based on the probe/meter efficiency, is given by Equation A3.

$$C_{Calib} = \frac{Q_{Calib}}{X_{Calib(h)} * K(h)} \quad \text{(A3)}$$

where Q_{Calib} = calibration source strength - the value of the ^{241}Am standard used for calibration (4.8 microCuries ^{241}Am in our case)

$X_{Calib(h)}$ = FIDLER meter reading for the calibration source, Q_{Calib}

and K(h) = FIDLER probe geometry constant (approximately 0.42 m^2 as determined previously).

[A2] Draft Report of the "US Army RADCON Team Participation in NUWAX-81," US Army Armament Research and Development Command, Ballistic Research Laboratory, June 1981.

The probe geometry constant, as discussed in Reference A2, applies only to a FIDLER probe with the face 30 cm above a fairly uniformly contaminated infinite flat area. The calibration constant can be now calculated for a meter reading of 30,000 cpm.*

$$C_{Calib} = \frac{4.8\ \mu Ci\ ^{241}Am}{30x10^{3} cpm\ *\ 0.42\ m^{2}}$$

or

$$3.8x10^{-4}\ \frac{\mu Ci\ ^{241}Am}{m^{2}}$$

The next step is to convert microCuries 241Am into micrograms 241Am and then micrograms 241Am into micrograms 239-242Pu. Equations A4-A6 are used for this purpose.

$$R = (\text{specific activity of } ^{241}Am) * \text{fractional weight of } ^{241}Am \text{ in contaminate}) \qquad (A4)$$

$$\text{where specific activity of } ^{241}Am = (\ 7.14x10^{-6}\ \frac{dpm}{\mu g}\ )*(\ \frac{1\ min}{60\ sec}\ )* (\ \frac{1}{3.7x10^{-10}}\ \frac{Ci}{dps}\ )*(10^{6}\ \frac{\mu Ci}{Ci}\ ) \qquad (A5)$$

($7.14x10^{6}$ = the alpha specific activity for ^{241}Am (a constant) and the remaining three values are standard conversion factors)

$$\text{and fractional weight of } ^{241}Am \text{ in contaminate} = \frac{\%\ ^{241}Am(1982)}{\%\ ^{239-242}Pu(1982)} = \frac{11.55\%\ ^{241}Am}{88.9\%\ ^{239-242}Pu} \qquad (A6)$$

(See Table A1 for fractional weights.)

$$\therefore \quad R = 0.418\ \frac{\mu Ci\ ^{242}Am}{\mu g\ ^{239-242}Pu}$$

*A typical value observed during the calibration process when the 4.8 microCurie standard was used.

Now the plutonium calibration constant can be calculated using Equation A7.

$$^{PC}Calib = {}^{C}Calib * R \qquad \text{(A7)}$$

or

$$^{PC}Calib = \left(\frac{3.8x10^{-4}\ \mu Ci\ ^{241}Am}{cpm\ \ m^2}\right) * \left(\frac{0.418\ \mu Ci\ ^{241}Am}{\mu g\ ^{239-242}Pu}\right)$$

$$= \frac{9.1x10^{-4}\ \mu g^{239-242}\ Pu}{cpm\ \ m^2}$$

Equation A8 then calculates the areal density of plutonium contamination dispersed on the ground in area D for the following assumptions:

1) The calibration meter reading was 30,000 cpm.
2) FIDLER probe height is 30 cm.
3) The contamination is areal or near approximation thereof.
4) The FIDLER is electronically set up for the 241 Am 60 kev gamma rays.

$$c = {}^{PC}Calib * (X(h) \qquad \text{(A8)}$$

where X(h) is the FIDLER meter reading in cpm

$$\therefore \quad c\ \frac{\mu g^{239-242}Pu}{m^2} = \left(\frac{9.1x10^{-4}\ \mu g^{239-242}\ Pu}{cpm\ m^2}\right) * X(h)\ cpm\ .$$

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